

# PREPARATION AND CHARACTERIZATION OF Pt NANOCATALYST ON TUNGSTEN BASED SUPPORT FOR ALKALINE FUEL CELLS APPLICATIONS

Lj.Gajić-Krstajić<sup>1</sup>, N.R.Elezović<sup>2</sup>, B.M. Babić<sup>3</sup>, P.Ercius<sup>4</sup>, V.R.Radmilović<sup>5</sup>, N.V.Krstajić<sup>5</sup>, Lj.M.Vračar<sup>5</sup>,

<sup>1</sup>Institute of Technical Sciences of the Serbian Academy of Sciences and Arts, Belgrade, Serbia, <sup>2</sup>Institute for Multidisciplinary Research, University of Belgrade, Belgrade, Serbia, <sup>3</sup>Vinča Institute of Nuclear Sciences, Belgrade, Serbia, <sup>4</sup>LBNL University of California, Berkeley, USA, <sup>5</sup>Faculty of Technology and Metallurgy, University of Belgrade, Belgrade, Serbia

## 1. Introduction

- Alkaline fuel cells (AFCs) are promising future energy providers [1];
- Many requirements regarding both catalyst support and catalyst material still remain unresolved;
- Development of inexpensive electrocatalysts for anode and cathode reactions, with high activity and corrosion and chemical stability is required;
- Platinum and Pt based catalysts have been recognized as excellent catalysts for oxygen reduction reaction. However, the problem is high costs;
- The supporting material for the catalysts is very important - it should be a good combination of excellent electronic conductivity and corrosion resistivity. Carbon or graphite is the most widely used catalyst support. However, during recharge of the fuel cell at high potentials, at the air electrode, carbon corrosion reaction could proceed irreversibly.
- Tungsten based catalyst supports have been investigated as promising materials for fuel cells applications [2].
- The motivation of the present work was to synthesize and characterize tungsten carbide nano-powder support and to deposit Pt nanoparticles on it, so as to follow the kinetics of the ORR reaction in an alkaline electrolyte, and to compare the activity of this catalyst with Vulcan/Pt catalyst.

## 2. Experimental

### 2.1. Catalyst preparation.

- Nanoparticles of  $WO_3$ , as a starting material, were obtained by dissolution of W-powder in  $H_2O_2$  solution with addition of 2-propanol and  $H_2O$ .  $WO_3$  particles then separated by centrifugation and dried at  $80^\circ C$ , overnight. 2g formaldehyde and 1.32 g resorcinol were dissolved in 9.6 ml  $H_2O$ , with addition of 0.0132 g  $Na_2CO_3$  and 2.46 g  $WO_3$  powder. This suspension was vigorously stirred at  $50^\circ C$ , for one day, and at  $85^\circ C$ , for three days. The resulting gel was freeze dried and calcinated at 1173 K in Ar flow.
- The WC supported Pt (10 wt.%) catalyst was prepared by borohydride reduction method[1].

### 2.2. Cell and electrode preparation.

- 4 mg of electrocatalyst, 1 ml ethanol and 50  $\mu l$  Nafion solution (5 wt.% Aldrich solution) was first ultrasonicated for 15 min to obtain a well-dispersed ink and then transferred on the surface of the gold electrode and dried at  $80^\circ C$  for 10 min to obtain thin film. The Pt loading was 8  $\mu g$  of Pt.

### 2.3. Electrode characterization.

- XRD analysis;
- STEM-HAADF and EELS measurements;
- Electrochemical characterisation: cyclic voltammetry technique and rotating disc electrode measurements.

## 3. Results and discussion

### 3.1. XRD and TEM analysis

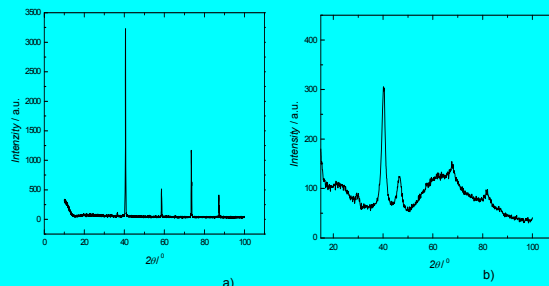


Fig.1. a) XRD diffraction patterns of WC support; b) XRD diffraction patterns of WC/Pt catalyst.

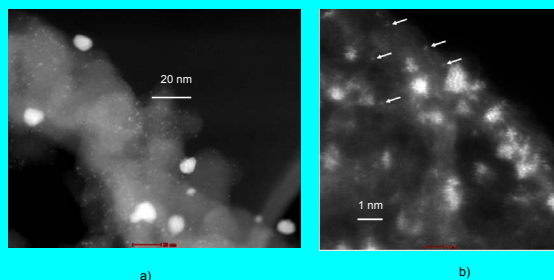


Fig.2. STEM images of the a) WC support, b) WC/Pt catalyst:

### 3.2. Cyclic voltammetry and ORR results

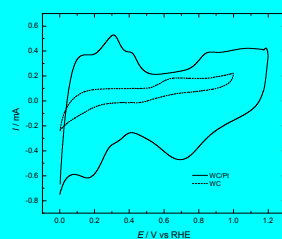


Fig.3. Cyclic voltammograms obtained at WC substrate and WC/Pt electrode; sweep rate of  $100 \text{ mV s}^{-1}$ ,  $N_2$  saturated  $0.1 \text{ mol dm}^{-3}$  NaOH solution..

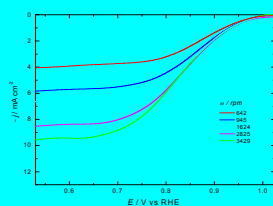


Fig.4. Polarization curves (positive-going sweeps) obtained with RDE, as a function of rotation rate, for ORR in  $0.1 \text{ mol dm}^{-3}$  NaOH solution, at WC/Pt electrode. Current densities are normalized to the geometric surface area.

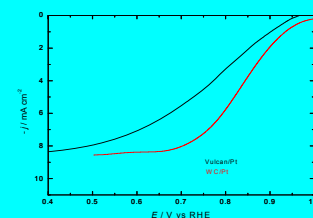


Fig.5. Polarization curves (positive-going sweeps) obtained with RDE, for ORR in  $0.1 \text{ mol dm}^{-3}$  NaOH solution, with a rotation rate 3040 rpm, at WC/Pt and Vulcan/Pt electrodes.

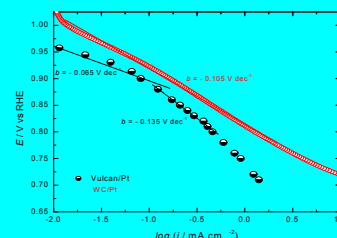


Fig.5. Tafel plots normalized to the electrochemically active surface area for  $O_2$  reduction in  $0.1 \text{ mol dm}^{-3}$  NaOH at Vulcan/Pt and WC/Pt electrodes.

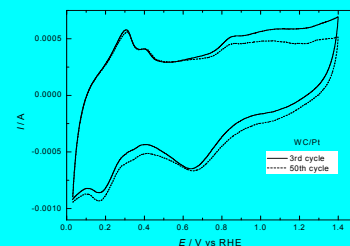


Fig.6. Cyclic voltammograms (scan rate  $100 \text{ mV s}^{-1}$ ) obtained at WC/Pt catalyst, after 3 and 50 cycles, showing high stability of the catalyst.

## 4. Conclusion.

- Tungsten carbide as islands deposited on nano-tungsten particles was successfully synthesized, characterized and used as a support for Pt based catalyst.
- The synthesized catalyst, in comparison with Vulcan supported one, showed better catalytic activity towards oxygen reduction, expressed through the specific current densities at the constant potential, especially in the potential range of practical interest ( $0.85 - 0.90 \text{ V}$  vs RHE).
- New synthesized WC/Pt is proved to be more stable than carbon based catalyst.

## Acknowledgment

This work was financially supported by the Ministry of Science and Technological Development, Republic of Serbia, under Contract No. 172054. Electron microscopy characterization was performed at the National Center for Electron Microscopy, which is supported by the Office of Science, Office of Basic Energy Sciences, of the U.S. Department of Energy under Contract No. DE-AC02-05CH11231.

## References

- J.R.Varcoe, R.C.T. Slade, Fuel Cells, 2005, 5, 187-200.
- E. Antolini, E.R. Gonzalez, Appl. Catalysis B: Environmental, 96(2010)245-266.
- K.W.Park, K.S.Seul, Electrochem.Communications 2007, 9, 2256-2260.